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Immediate and Long-term Results of Carotid Endarterectomy

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We review the long-term results of carotid endarterectomy in 200 consecutive patients operated on from 1980 to 1987. The patients were part of an ongoing study using duplex scanning to assess the status of the carotid bifurcation before and after endarterectomy. The average follow-up for the patients was 31 months. The indications for surgery were transient ischemic attacks in 87 (43.5%) and stroke in 36 (18%) patients; 77 patients (38.5%) were asymptomatic. In 176 sides (88%), the degree of stenosis exceeded 50% in terms of diameter reduction. The perioperative stroke rate was 2.3% in patients with transient ischemic attacks, 2.8% in patients with strokes, and 1.3% in asymptomatic patients. There was one perioperative death (0.5%). There were five occlusions of the internal carotid artery, one during the perioperative period and four after discharge; in three patients the occlusion was associated with the development of a stroke. There was a restenosis rate of 19.7% secondary to myointimal hyperplasia; such lesions did not appear to contribute to new ischemic events during or after their development. The mean stroke incidence after the decision was made for carotid endarterectomy was 2.8%/yr in the patients with transient ischemic attacks, 6.2%/yr in the patients with stroke, and 0.65%/yr in the asymptomatic patients. The annual death rate was 6% for the entire group, 5.5%/yr in the patients with transient ischemic attacks, 9.2%/yr in the patients with stroke, and 4.6%/yr in the asymptomatic patients. (*Stroke* 1989;20:1138-1142)

In recent years, investigators have raised justifiable concerns about carotid endarterectomy and its role in the treatment of carotid bifurcation disease.¹ If the operation is to be useful, it must have a combined morbidity/mortality less than that with conventional nonsurgical therapy. Carotid endarterectomy has not proven to be effective in prolonging life as most patients with carotid artery stenosis also have coronary artery disease, with the latter being the most common cause of death.

Most reports of carotid endarterectomy have included the early and late events without relating them to the status of the bifurcation or to changes that might occur over time. This is an important point since the possible effectiveness of carotid endarterectomy does not end with completion of the operation. There are many questions of interest, which include 1) Does the bifurcation remain free of disease after surgery, and for how long?; 2) How

often does the internal carotid artery occlude during and after surgery?; and 3) Are the events that occur after surgery related to residual disease in the bulb, or do they occur from other causes?

In an attempt to answer these questions, we report the long-term results in 200 consecutive patients who underwent carotid endarterectomy from 1980 to 1987 and were monitored by repeated ultrasonic duplex scanning to assess the status of the operated segments.

Subjects and Methods

All 200 patients (123 men and 77 women) underwent carotid endarterectomy performed by members of the vascular surgery section at the University Hospital (120 patients) and the Pacific Medical Center (80 patients) from 1980 to 1987; the patient's mean \pm SD age was 66 ± 8.5 years. Average follow-up was 31 months.

The indications for surgery were transient ischemic attacks (TIAs) in 87 (43.5%) and stroke in 36 (18.0%); 77 patients (38.5%) were asymptomatic. Patients who had nonspecific visual complaints, dizziness, or syncope not associated with a lateralizing neurologic event were considered to be asymptomatic.

Preoperative duplex scans were obtained in 193 patients (96.5%);² the other seven patients, because

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TABLE 1. Summary of Data for Groups of Patients by Indication for Carotid Endarterectomy

Events	Indications for endarterectomy							
	All patients (N=200)		Transient ischemic attack (n=87)		Stroke (n=36)		Asymptomatic (n=77)	
	No.	%	No.	%	No.	%	No.	%
Perioperative								
Death	1	0.5	1	1.1	0	0	0	0
Ipsilateral stroke	4	2.0	2	2.3	1	2.8	1	1.3
Transient ischemic attack	4	2.0	3	3.4	0	0	1	1.3
Postoperative								
Contralateral stroke	1	0.5	0	0	0	0	1	1.3
Ipsilateral stroke	1	0.5	0	0	0	0	1	1.3

of their presenting complaint, went directly to angiography and then to surgery. The diameter reduction of the bifurcation on the side of the operation was 1–15% stenosis in five sides (2.5%), 16–49% stenosis in 19 sides (9.5%), 50–79% stenosis in 83 sides (41.5%), and 80–99% stenosis in 93 sides (46.5%). Thus, 88% of the patients who underwent carotid endarterectomy had severe or very tight stenoses of the carotid artery. The 24 patients with minimal to moderate stenosis were all symptomatic and were thought to have had events secondary to emboli.

After surgery, each patient was asked to participate in the follow-up program. The patient was first seen 3 months after surgery, then at 6-month intervals for a year, and then yearly thereafter. At each follow-up visit, the patient received a standard set of questions about his or her health history in the interim, with particular emphasis on the occurrence of neurologic events.³ A complete duplex scan was repeated at each visit to assess the status of the carotid bifurcation on both the operated and the nonoperated sides. The status of those patients who failed to return for follow-up visits was assessed in the following manner: 1) their hospital charts were reviewed; 2) they were contacted by telephone; 3) if we could not reach them by telephone, they were written a letter; and 4) if all attempts to reach them failed, a search for a death certificate was made.

When an event was recorded at the follow-up visit, particular attention was paid to the specific area involved, its permanence, and its relation to the operated side. In questionable cases, the hospital chart was reviewed to verify the nature of the event. The events tabulated were 1) stroke, 2) TIA, 3) reversible ischemic neurologic deficit, 4) restenosis, and 5) the development of total occlusion; they were classified by their time of occurrence. Perioperative (immediate) events occurred <24 hours, postoperative events occurred >24 hours but ≤30 days, and late events occurred >30 days after surgery.

Thirteen patients underwent bilateral carotid endarterectomy during the study period. They were included in the life table until the second operation,

at which time they were censored from the analysis and considered a separate group.

The data were coded and entered into a personal computer and then transferred to a mainframe computer for statistical analysis using the Statistical Package for the Social Sciences (SPSS).⁴ Death and event rates were computed using the life table format described by Kaplan and Meier.⁵ Rates were compared among groups by the Lee-Desu statistic included in the SPSS survival procedure.

Results

Of the 200 patients, 48 (24%) did not get follow-up duplex scans: two lived outside the country, seven outside the state, and 11 outside King County; three could not return because of illness, three simply refused to return, five died, six disappeared, and 11 were lost in the follow-up system. Only seven patients were completely lost to follow-up for any postoperative visit. After reviewing state death certificates, it was learned that one lost patient had died. The results are summarized in Table 1.

The life table cumulative stroke rate on the operated side for all patients was 10.3%, or 2.6%/yr for the 4 years (Figure 1). For patients who underwent carotid endarterectomy for TIAs, the cumulative stroke rate was 11.2%, or 2.8%/yr. Among those who had sustained a stroke as the indication for surgery, the cumulative stroke rate was 24.8%, or 6.2%/yr. Among the asymptomatic patients, the cumulative stroke rate was 2.6%, or 0.65%/yr.

At 4 years 76% of the patients were still alive, giving an annual death rate of 6%. By indications for surgery, the following were noted: in the TIA group 78% were alive (annual death rate of 5.5%) and of those operated on for stroke 63.4% were alive (annual death rate of 9.2%). Asymptomatic patients appeared to fare better than those who had a stroke ($p<0.02$); 81.7% were alive at 4 years, giving an annual death rate of 4.6% (Figure 2).

There were 35 deaths during follow-up. Three were stroke-related, 13 were secondary to myocardial problems, five were due to malignancy, and nine were due to other causes; in five patients, we were not able to establish the cause of death.

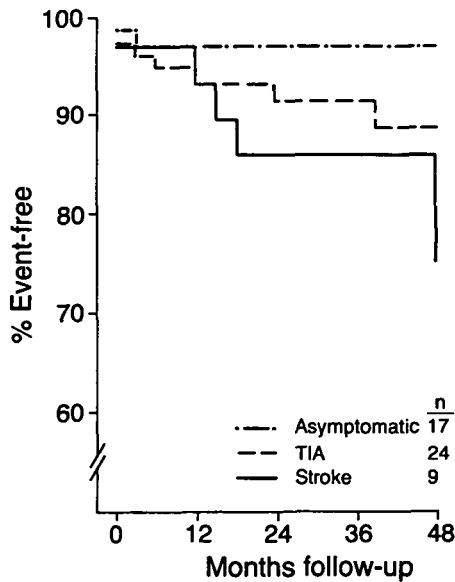


FIGURE 1. Life table for stroke events in three groups of patients by indication for carotid endarterectomy. There are no significant differences between groups. n, patients in follow-up program at 48 months. TIA, transient ischemic attack.

Whereas some do not consider the occurrence of transient ischemic events to be important in considering the outcome of therapy, we included such events in our analysis. There was an incidence of 8.0% for all patients, giving an annual rate of 2%/yr. For patients with TIAs as the indication for surgery, the cumulative incidence was 12.9%, or 3.2%/yr. For

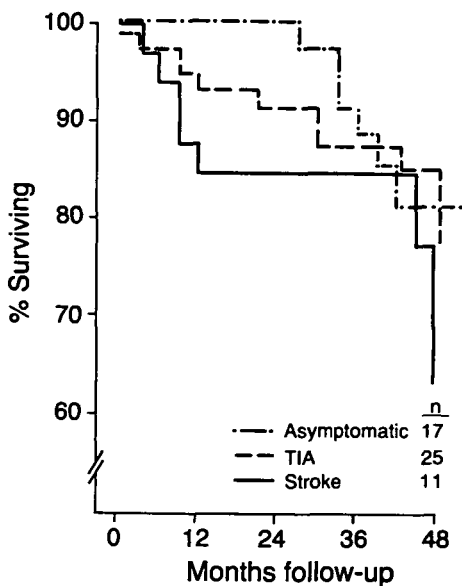


FIGURE 2. Life table for survival in three groups of patients by indication for carotid endarterectomy. Only significant difference is between asymptomatic patients and those operated on for stroke ($p < 0.02$). n, patients in follow-up program at 48 months. TIA, transient ischemic attack.

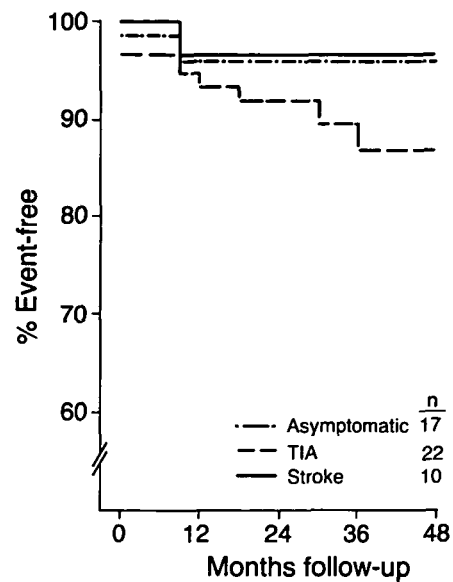


FIGURE 3. Life table for transient ischemic events in three groups of patients by indication for carotid endarterectomy. There are no significant differences between groups. n, patients in follow-up program at 48 months. TIA, transient ischemic attack.

stroke patients, the cumulative incidence was 3.4%, or 0.9%/yr. For asymptomatic patients, the cumulative incidence was 4.2%, or 1.1%/yr (Figure 3).

Five occlusions occurred in the entire series, one perioperatively and four postoperatively. The immediate (perioperative) occlusion rate was 0.5%, with the late rate 2.5%. The patient with immediate occlusion had associated hemiparesis and aphasia; he was returned to the operating room for correction and obtained approximately 95% recovery from the event. In the remaining four patients, two had asymptomatic occlusions. One of these was detected on Day 61, at the first follow-up visit; when the occlusion occurred is unknown. The other patient was found to have an occlusion on Day 974; he had been last seen on Day 609, when the carotid artery had a 1–15% stenosis. One patient who developed a stroke associated with an occlusion was readmitted for the stroke on Day 702; he had been last seen on Day 245, when he had a stenosis of 16–49% in the bifurcation. The fourth patient was found to have an occlusion on Day 123, when he was asymptomatic; however, on Day 304 he was admitted with a stroke on the side of the occlusion.

As noted, 13 patients underwent a second endarterectomy during follow-up. The average interval from the first to the second operation was 16 months. No perioperative events occurred in any of these patients for either endarterectomy. The average follow-up was 37 months for the first and 22 months for the second side. The indications for the second operation were TIAs in three and contralateral occlusion and stroke in one patient; nine patients were asymptomatic but developed high-grade

lesions. One late stroke occurred on the side of the first endarterectomy. Another patient developed a transient ischemic event on the side of the first operation. There were no late strokes, and only one transient ischemic event related to the second side occurred during follow-up.

Long-term follow-up duplex scans were available in 152 patients (76% of the original 200). An early myointimal restenosis (>50% diameter reduction), was found in 38 (25% of the 152). In two (5.3% of the 38), the lesion regressed, giving an overall restenosis rate of 19.7%. Three patients underwent a second carotid endarterectomy.

Discussion

If carotid endarterectomy is to be used to treat atherosclerosis of the carotid bulb, it must be shown to be both a safe and a durable operation over the long term. While studies have looked at the event rate after surgery, no studies have examined the operated segment over time to determine its fate and its relation to long-term outcome. An important item that needs to be determined is to the extent to which the carotid bulb remains free of disease after the atheroma is removed. It is now recognized that two separate processes that may influence outcome can occur after endarterectomy.

The first and most dramatic process is the development of myointimal hyperplasia. This lesion, which appears to consist primarily of smooth muscle, can develop within weeks and is usually complete by the end of the first 2 years. The lesion itself is smooth and does not appear to ulcerate. Most importantly, it does not appear to place the patient at risk for the development of ischemic events. Twenty-five percent of our patients with long-term follow-up duplex scans developed a >50% stenosis, but as we showed earlier,⁶ some of these lesions appeared to regress. This occurred in 5.3% of our patients with myointimal hyperplasia, giving an overall restenosis rate of 19.7%.

The benign nature of myointimal hyperplasia must be emphasized. Reoperation should not be done unless the patient develops symptoms and signs appropriate to the lesion. Another worrisome concern with regard to myointimal hyperplasia is its potential for progressing to a total occlusion. If this were to occur, it might place the patient at risk for an ischemic event. Based on the results of this study and our previous one, this appears unlikely; therefore, it is safe simply to follow the patient with repeat studies.

The second process is occlusion of the internal carotid artery. An important issue is the rate at which it occludes after endarterectomy. While some patients may have an occlusion without sustaining a neurologic event, up to 50% have a problem if the collateral circulation to that hemisphere is inadequate. In our present study, one perioperative occlusion secondary to the development of a platelet thrombus was immediately corrected. The patient

sustained an acute stroke from which he partly recovered. No technical problem was found to explain the occurrence, and the artery remained patent to the time of his death 3 years later. Late occlusions occurred in four patients; two had a stroke. In the two patients who did not sustain an event, the occlusions were detected at a follow-up visit, on Day 61 in one patient and Day 974 in the other. The latter patient was noted to have only a minimal lesion (1–15% stenosis) on Day 609. The reason these arteries occluded is unknown. One patient who had a stroke associated with his occlusion was found to have a moderate stenosis on Day 245 but was admitted with a stroke on Day 702 and was found to have an occluded internal carotid artery then. This *may* have represented progression of a myointimal lesion. The fourth patient was found to have an occlusion on Day 123, within the time frame that myointimal hyperplasia develops. At that time he was asymptomatic, but he was admitted on Day 304 with a stroke on the side of the occlusion.

Are these results with regard to the development of a total occlusion better than might be expected with nonoperated lesions? In our two previous studies, the chance of an internal carotid artery occluding was very low except when the degree of narrowing exceeded 80%. In our 1984 study,⁷ eight of 25 patients (32%) with high-grade lesions went on to have occlusions of their internal carotid arteries. In our later study,⁸ of the 73 sides with a >80% stenosis that were not treated surgically, 11 (15%) developed an occlusion. These results suggest that carotid endarterectomy may be better than medical management for preserving patency of the internal carotid artery, especially when a preocclusive lesion is found. Whether antiplatelet therapy will preserve patency of the internal carotid artery has not been established due to the fact that no trial has looked at the site of disease over time with a modality such as duplex scanning to determine this fact.⁹

Is it important to maintain patency of the internal carotid artery? Patients who have occlusions of their internal carotid arteries and have no symptoms at the time are not risk-free for events later. In the study by Cote et al,¹⁰ the annual incidence of events on the side of an occlusion was approximately 5%. In our own study of 212 patients with this problem, the annual stroke rate on the side of the occlusion was 3%.¹¹ These stroke rates are very similar to those predicted by the Committee on Health Care Issues of the American Neurological Association for patients who have TIAs as the presenting complaint.

Since we have only historical controls and since the results of randomized trials are years away, it is not possible to state whether the long-term results we report are better than those expected with conventional therapy, which includes control of risk factors and the use of antiplatelet therapy. All we can state is that our early results are similar to

those reported by authors from other institutions who have carefully looked at this problem over time. Till et al¹² showed that their 30-day morbidity/mortality for patients with TIAs was 3%, nearly identical to ours. It is unlikely that we will be able to improve significantly on these early rates, given the nature of the problem and the types of patients who undergo carotid endarterectomy.

It appears quite clear that carotid endarterectomy may not be able to improve the long-term survival of patients. The poorest results were in patients with strokes as indications for surgery, the best in asymptomatic patients. In patients with TIA, our 4-year survival was 78%, which compares favorably with the results of Howard et al,¹³ who found 84% of their patients alive at 4 years. For asymptomatic patients, our results were not quite as good as those of Chambers and Norris,¹⁴ who found 91% of their patients alive at 4 years (compared with 82% in our series). Clearly, the issue of coexisting coronary artery disease is the dominant factor that determines long-term survival in patients undergoing carotid endarterectomy.

Finally, for each category of patients the ongoing event rate is of concern. The etiology of such events remains largely unknown. It appears from our study that the carotid bifurcation may not be the responsible site in some patients. It is clear that a diligent search for etiologic factors must continue whenever a patient presents with an ischemic event.

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